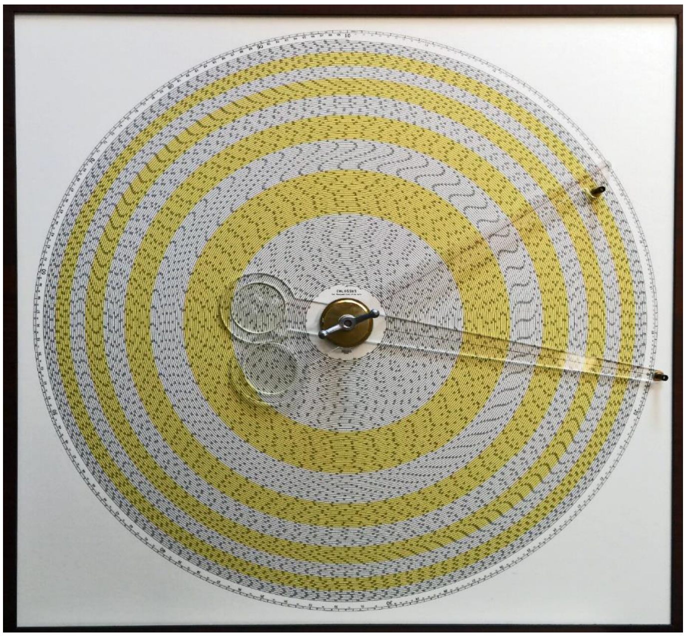
Long-Scale Slide Rules: From Words to Scales - Part 1.

Jose Fernandez

Introduction

[This very long article was first published in The Proceedings of the 24th International Meeting of Slide Rule Collectors. Part 1 of the article is reproduced here for a wider audience with Part 2 following later.]

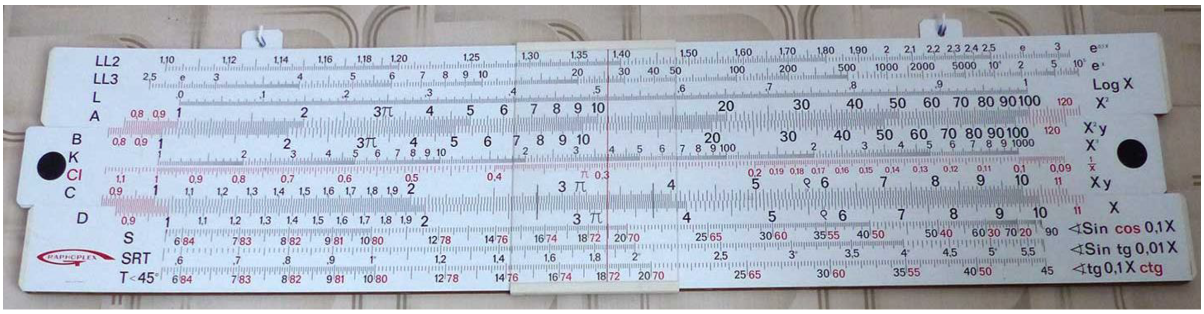
I believe that nobody will doubt that the slide rule in the following picture has a very <u>long scale</u>:



Colossus 2, by Jim Bready.

With a diameter of less than a meter and a spiral of 135 turns, the achieved scale length is really impressive…

On the other hand, you may look at this demonstration slide rule:

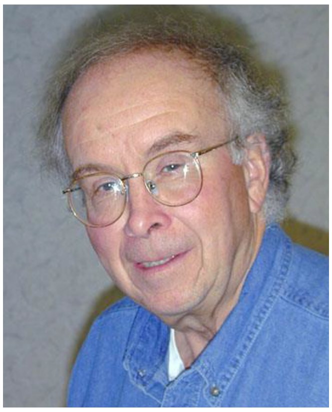


Graphoplex 1614 demonstration slide rule (www.photocalcul.com).

And conclude, for sure, that it is quite <u>big</u>… However, would you say that it has <u>long</u> scales?

In the end, it is a matter of agreeing the right meanings of the words which we use to classify our slide rules…

Long-Scale Slide Rules Champion



Ed Chamberlain:

1938 – 2017.

Speaking of long-scale slide rules is to speak of one dear slide rule collector who unfortunately left us at the end of last year: Ed Chamberlain. One of Ed's preferences as a collector was long-scale slide rules (LSSR). He dedicated many years to finding, studying and classifying LSSRs, and many of his published articles show specimens with long scales. In the end, he developed quite an extensive list of long-scale slide rules. This list was shared with Rod Lovett and David Rance, who worked it up into a website for all of us to enjoy: http://osgalleries.org/longscale/index.html.

Unfortunately, the shared list did not include pictures, and so, although Rod and David have been looking for them, a lot of these rules still need a graphic representation. All collectors are encouraged to collaborate with Rod and David in filling this amazing list with pictures!

In this article, when a picture has no reference of origin, it comes from this collection or it is my own.

Nevertheless, although for sure Ed had a very clear idea of what a long-scale slide rule was, I am not aware of any list of detailed definitions of all possible LSSRs, so that we all may participate in taking care of this LSSR list and contribute with new models. Thus, from what he wrote for the Journal of the Oughtred Society, [1] & [2], I have been talking with Rod and David Rance to generate this article and to promote a global agreement about LSSR classification.

A Long-Scale Slide Rule (LSSR)

Purpose of a LSSR

Generally speaking, standard slide rules were designed with C and D scales which measured about 25 centimetres, producing a device easy to handle, with a capable set of scales, and with enough precision for most technical calculations. There is plenty of documentation proving this last statement. From time to time, however, technicians or slide rule users had to face problems where the precision of a slide rule was not enough to provide a good result.

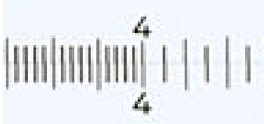
To solve such problems, slide rule manufacturers developed more complex designs providing tools with increased precision. The logarithmic scale in a slide rule is a graphical layout that is dependent on the capability of the human eye to separate two marks in it. As this capability cannot be increased (calculations usually have to be done with the naked eye), the only way to increase precision is to have scales with longer distances between the main marks, thereby enabling more intermediate marks.

The Precision Standard

Hence, we need to develop longer scales to increase the calculating precision, that is, the number of digits you can read in the results from the slide rule. And what are the basic results in a slide rule? Those from multiplications or divisions. Calculating with a slide rule will include more or less complex factors, but, in the end, most of the operations end up reading the results from the C or D scales. So, the precision of C and D scales inform the precision of most of the results that will be found while working with a slide rule.

In general, then, we will refer to a long-scale slide rule, (LSSR), when the scales used to multiply and divide (normally labelled C or D) have a precision higher than the common 25-centimetre C and D scales. Of course, this is what Ed already had stated in his JOS article [2]: *The "long scales" … are the single-cycle number calculating scales (sometimes broken into segments) used for multiplication and division … with calculating scale lengths greater than the lengths of the C and D scales on common 25cm slide rules.*

Of course, the precision is given by the number of divisions marked in the scales. Let us see, then, the basic precision of a one-decade (single-cycle), 25-centimetre scale, at its beginning, middle and end sections:



Beginning, middle, and end sections of C and D scales in a 25 cm slide rule.

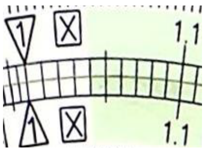
We can see that there are ten divisions (marks) from 1.0 to 1.1, five divisions between 3.9 and 4.0, two or five divisions between 4.0 and 4.1, and 20 divisions from 9.0 to 10.0.

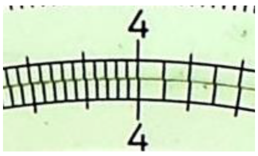
We can classify the different LSSRs depending on how this precision increase was achieved by their manufacturers. In a desktop slide rule there are two properties that will be compromised when higher precision scales are designed. First, we can appreciate the ease of handling (to calculate while over papers in a table or to take somewhere else). Then, there is also the number of scales, and their layout, helping to make calculations easily.

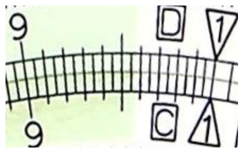
Circular Slide Rules

We can also establish a standard precision in circular slide rules in comparison with that which is given by a 25 cm C or D linear scale. A circumference of twenty-five centimetres is achieved with a diameter of about eight centimetres. Then, as a rough estimation, a common-precision circular slide rule would be about twelve centimetres in diameter, assuming the C and D scales to be placed at about two thirds of the overall diameter.

This is the case, for example, of a Faber Castell 8/10.





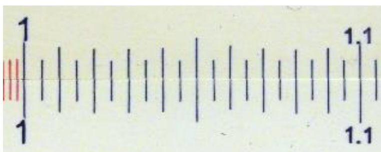


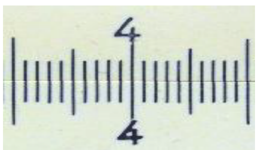
1.0 - 1.1: 10 marks. **3.9 – 4.0: 5 marks;4 .0 – 4.1: 2 marks.** **9.0 – 10.0: 20 marks.**

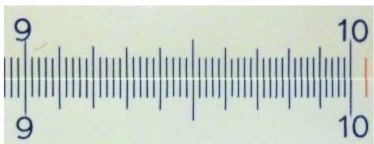
Beginning, middle and end sections of C and D scales in a desktop circular slide rule.

Longer, Linear LSSRs

The first solution in the list was the manufacture of a longer slide rule, so that a longer scale could be drawn, but keeping the same layout of scales. Although there are some intermediate designs, like Nestler 23a, of 36 cm, with some increase in the number of marks, I will refer to the marks in a 50 cm slide rule, the Faber Castell 4/54:



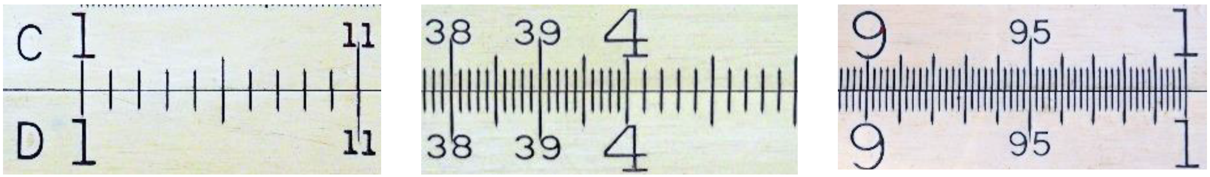




1.0 - 1.1: 20 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 50 marks.**

Beginning, middle and end sections of C and D scales in a 50 cm slide rule.

We can see twenty divisions from 1.0 to 1.1, ten divisions between 3.9, 4.0 and 4.1, and fifty between 9.0 and 10.0. So, with this length increase we get double the number of marks in the first two sections, while the factor is 2.5 at the end section, pointing clearly to an effort to provide more precision at this right end, where the logarithmic scale is more compressed. This effort may be seen more clearly, for example, in a K+E N4096, where in the beginning section there is the same number of marks as on a 25 cm slide rule, while the number of marks is increased in the middle and end sections.



1.0 - 1.1: 10 marks. **3.9 – 4.0: 10 marks; 4.0 – 4.1: 5 marks.** **9.0 – 10.0: 50 marks.**

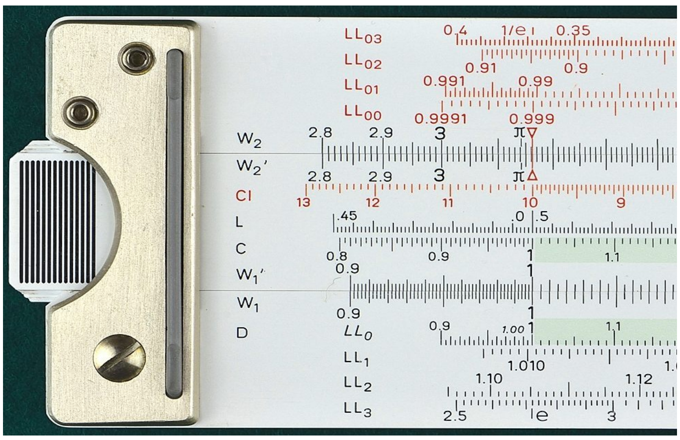
Beginning, middle and end sections of C and D scales in K+E N4096.

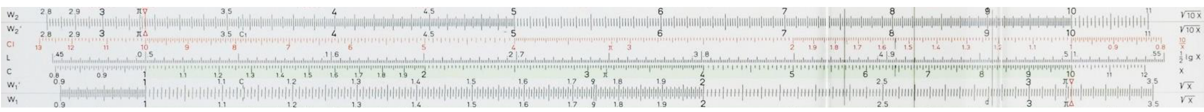
There are even longer slide rules, where the manufacturing process was really challenging, like the Nestler 24b, with 100 cm length, but equivalent number of marks like the 50 cm brothers. Clearly a longer design gets complicated to work with, (maybe even requiring a chair with wheels to go from one end to the other…).

A totally different approach is seen in demonstration slide rules. These are used to train students in the use of specific desktop models, and so they replicate exactly the same layout of these rules. Thus, demonstration SRs are big but are not “long-scale” slide rules.

Multi-segment, Linear LSSRs

This time the compromise is in the scale layout, by cutting the scales into some number of segments and placing them in a smaller-length slide rule. The most common ones have a 50 cm scale pair cut into two pieces and placed on a 25 cm footprint. As there are two scales, (like C and D), each with two segments, these are normally positioned on the slide edges and the matching body edges. An example is shown here of the W-W’ scales on the Faber Castell 2/83N, and the number of marks is the same as a 50 cm specimen (www.reglasdecalculo.com):

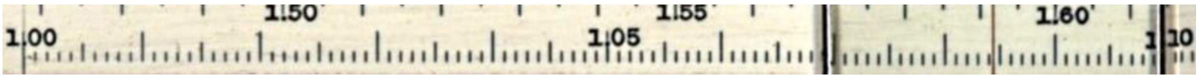




1.0 - 1.1: 20 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 50 marks.**

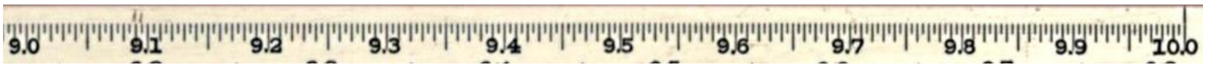
Two-segment scales W1+W2, W1’+W2’ on the Faber Castell 2/83N.

The evolution of this concept is either to increase the number of segments, or even to combine the multi-segment strategy with a longer device, like on a Hemmi 200, with 6 segments and 50 cm length. In this model there are a hundred marks between 1.00 and 1.10, fifty between 3.9 and 4.0, twenty between 4.0 and 4.1, and two hundred between 9.0 and 10.0 (www.sliderulemuseum.com):



1.0 – 1.1: 100 marks.

3.9 – 4.0: 50 marks; 4.0 – 4.1: 20 marks.

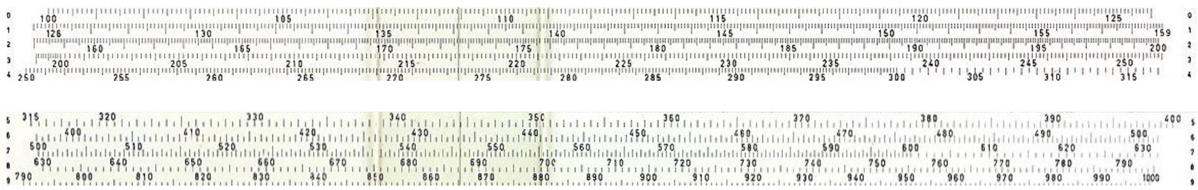


9.0 – 10.0: 200 marks (9.9 – 10.0: 20 marks).

Beginning, middle and end sections of 6-segment scales in Hemmi 200 slide rule.

The "tricky" Aristo 10065 System Gruter

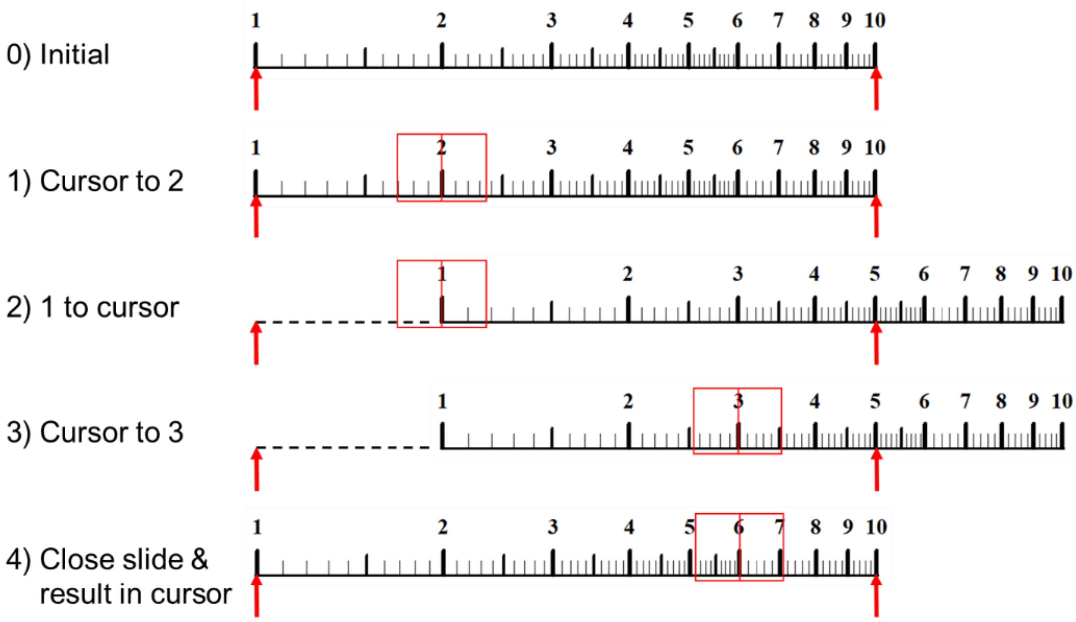
This desktop slide rule has a 10-segment scale, and so the resulting total length is of 250 cm. Five segments are located at the front of the slide, and five more are located at the back. Also, the instruction manual shows how to multiply and divide with that scale.



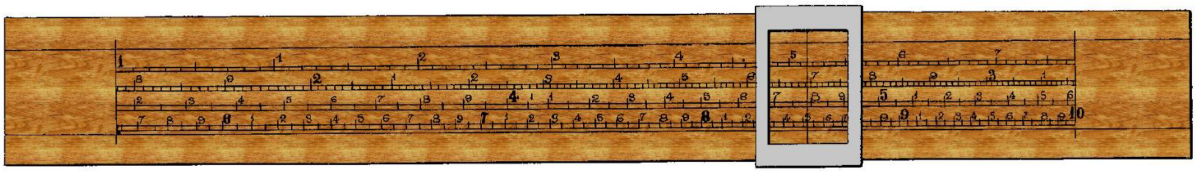
1.0 – 1.1: 100 marks. **3.9 – 4.0 – 4.1: 20 marks.** **9.0 – 10.0: 100 marks.**

0 to 4 (slide front) and 5 to 9 (slide rear) segments of Precision scale in Aristo System Gruter.

However, there is only one scale, and the multiplication method is, in fact, like a trick, as you can do it with any one-decade scale (with beginning and end indexes). For example, let us multiply 2 by 3…



I already learned this method of calculation with a single scale when studying a Spanish patent from Diego Ollero (4-segment single scale) [3].

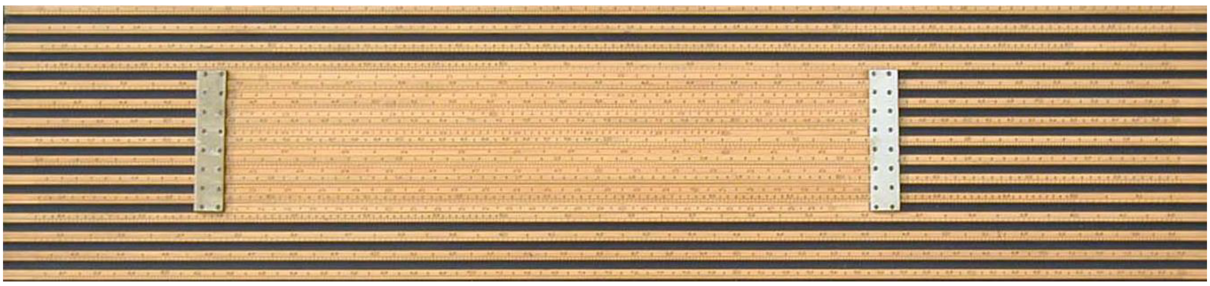


Simulation of slide rule prototype from Diego Ollero's patent FR358425A (1905).

So the Gruter slide rule is, in fact, two separate slide rules which can be considered a “common” desktop slide rule, and a “precision” slide rule with a single one-decade scale, with which you can multiply, divide and get logarithms (towards the L scale, again, with a specific process). Then, instead of the Aristo Gruter being a long-scale slide rule, I would prefer to consider it as a standard slide rule with an added “precision” long-scale. This “precision” scale on the Gruter slide rule is a kind of add-on to the rest of other scales on the rule. You can operate with all the other scales without the need of the “precision” scale (you don't have to use it). On the other hand, there are many long-scale slide rules that only multiply and divide, although the method of operation is normally easier. Maybe the point is in having the scale on the slide. Several slide rules have a single two-segment scale for square roots, but this is in the body, and any multiplication or division using this scale alone is not feasible (with a standard single cursor).

Gridiron LSSRs

When the C and D scales are divided into a large number of segments, it may be difficult to work on two numbers, one in segment 'n' of C and the other in segment 'm' of D. So, the idea was born to “spread out” the surfaces containing multiple segments into two gridiron layouts (the body and the slide), so that the scales intermingle. The slide may be lifted and placed so that the two numbers of interest are in contact with adjacent fixed scales. Thus there will be no need of a cursor, and the result will be in another pair of numbers that will be found within the gridiron (one number on the body and the other on the slide). The only requirement is that the rods of the body are larger than the rods in the slide (and also with some repetition from one rod to the other) to allow for some shifting of the slide and to make possible the matching of any numbers on a slide rod with any number on a body rod, while keeping all the slide contained within the gridiron body. Hannyngton's Extended gridiron, by Aston & Mander, is a typical example:



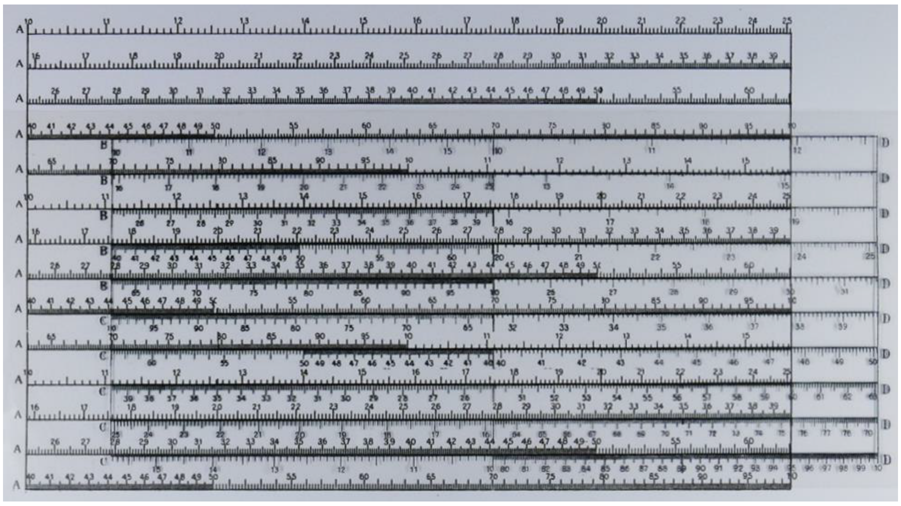
1.0 – 1.1: 50 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 100 marks.**

Hannyngton's Extended gridiron LSSR, by Aston & Mander.

However, the only operation possible is multiplication or division, (there may be a separate slide for square roots), but the precision and ease of use is high. From this came a paper system with a printed transparent slide, or other similarly cheap devices, such as the Graphic Counting Table shown below.

In this Table, however, the body has fourteen segments which implement a 3-decade scale (5, 5 and 4 segments with repeated parts), named “A”. Also, the slide has three different scales. It is divided vertically by half and the left half is divided horizontally in two quarters, generating the three respective areas. In the top left quarter there is a 5-segment “B” scale, equal to “A”; in the bottom left quarter there is a 5-segment “C” scale, equal to “B” but inverted. Then, at the right half there is a “D” scale, with ten segments, providing square roots of “A”.

Unfortunately, I do not have the instructions for this device, and therefore I do not know how the manufacturer expects it to be used. However, as the “A” scale is extended to cover “B” and “C” scales, some number in the “A” scale, but at consecutive decades, matches a number in “B” and its inverse in “C”. So, I would say that it is possible to combine multiplication and divisions as when using a regular slide rule's scale D (“A”), C (“B”) and CI (“C”). However, I would say that the scale “D” of square roots is to be used separately from “B” and “C”.

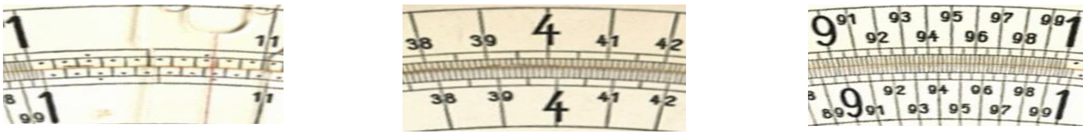


1.0 – 1.1: 10 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 50 marks.**

Graphical Calculating Table by Friedrich Schneider.

Larger Circular LSSRs

Following the same reasoning as for the linear slide rules, a first manufacturers' approach was to increase the disc size. However, we need to have more marks in the basic scales to consider a circular slide rule with a single-segment C and D scales as an LSSR. For example, the Tröger disc:



1.0 – 1.1: 20 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 50 + 10 marks.**

Beginning, middle and end sections of C and D scales in a Tröger disc

However, there is a type of circular slide rule that has only one fixed one-segment scale for multiplication and division… because it has a combination of two radial cursors, enabling full operation with all the other scales. The same “more-marks” principle also applies for these slide rules, such as the Gilson Binary:

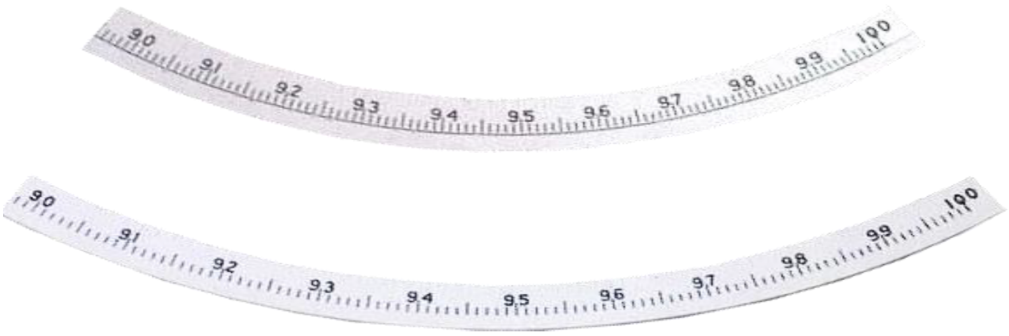
1.0 – 1.1: 20 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 50 marks.**

Beginning, middle and end sections of the one-decade scale in Gilson Binary.

In this case the full definition applies, as this is the basic scale for most of the calculations in the slide rule. The clear advantage of the circular slide rules is the smaller overall dimension, as compared to the equivalent linear long slide rules, making them still of simple handling.

Multi-Segment Circular LSSRs

Again, the compromise of the manufacturers is to cut a longer scale in several circular segments, to fit them onto a practical disc, and to place them in a multi-turn concentric layout, thus reducing the space for other scales. However, in circular slide rules the number of scale segments tends to be higher than the most common two-segment layout used in the linear desktop slide rules. For example, in the case of the Rotarule AA, there are at the back C and D long scales with four segments (sliderules.lovett.com):



End section of 4-segment C and D scales at the reverse of Rotarule AA.

There are fifty marks between 1.0 and 1.1, twenty from 3.9 to 4.0 and to 4.1, and a hundred marks from 9.0 to 10.0. However, having two segmented scales brings the disadvantage of the inner scales being shorter than the equivalent ones in the outer circumferences, and then the precision is given by the inner scale, leaving the outer scale with wider spaces. Because of this, then, I would say that most circular slide rules with longer multi-segment designs are of the two-cursor type with a single long-scale, with a number of turns ranging from 6 to 30 or higher, and taking the most advantages of a structure of increasing circumferences.

An example family of this type would be the pocket-watch slide rules by Fowler, a Jubilee Magnum being a longer sample:

1.0 – 1.1: 50 marks. **3.9 – 4.0: 50 marks; 4.0 – 4.1: 20 marks.** **9.0 – 10.0: 200 marks.**

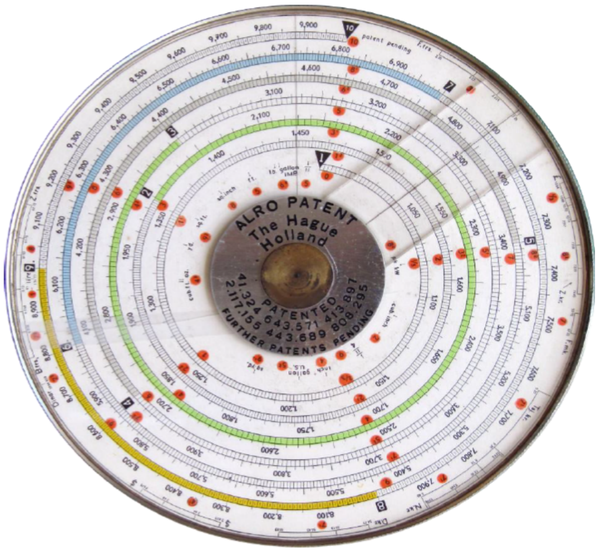
Beginning, middle and end sections of the 10-segment scale in Fowler's "Jubilee Magnum".

Nevertheless, having so many segments reduced the options for other scales, prioritizing precision. It seems that the option of a very long scale was more "feasible" in a circular slide rule, and so, the manufacturers, when focused on increasing precision, jumped into much longer layouts than in the linear designs, where having a series of different scales was preferred most of the time (with only two-segment long scales).

Spiral Circular LSSRs

Here, the manufacturers went a step further and converted a series of contiguous circular segments into a multi-turn spiral scale. Again, a single long scale to be used with two cursors. Well, I know of at least one model, the Ross Precision Type I slide rule, where a single cursor is used. However, the calculation is then based on the process shown in the chapter of Aristo System Gruter, but it is even more complicated having to cope with the 25 turns of the spiral [5]. In the Ross Type II there are already two cursors.

I believe that the spiral layout is more complex to develop than one with concentric segments, but the layout is easier to follow. Thus, I would say that it superseded the one with concentric segments for the newer models, once the technology was good enough. When there was a greater number of turns, the device was nearly always used only for basic multiplications and divisions, and some help was given to know at what turn to read the result.

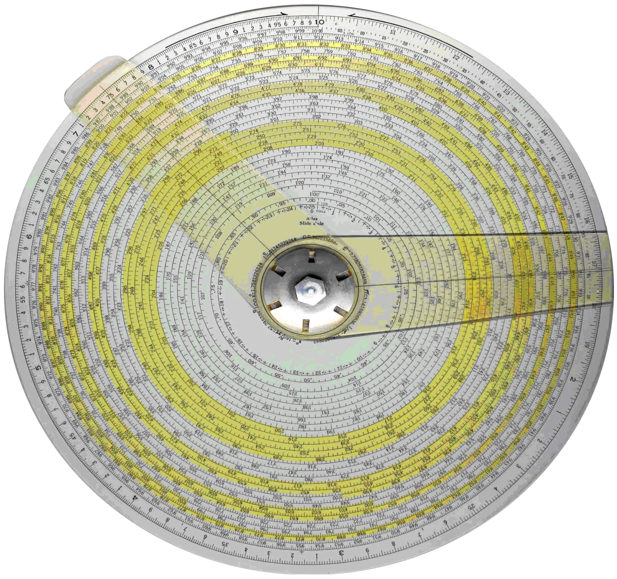


1.0 – 1.1: 50 marks. 3.9 – 4.0 – 4.1: 20 marks. 9.0 – 10.0: 200 marks.

Alro 1010 Commercial, with a 6-turn coloured spiral.

The compromise among ease of reading, the number of turns and the size of the device is normally critical, and requires accurate styling. It is the case of the Gilson Atlas III, that, using Ed's words [1]:

can be read with nearly the same precision as the Thacher cylindrical slide rule, and it can be done much easier and with considerably less complexity and much less cost.



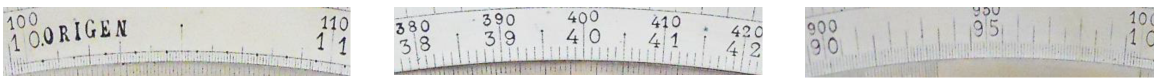
1.0 – 1.1: 100 marks. **3.9 – 4.0 – 4.1: 100 marks.** **9.0 – 10.0: 1000 marks.**

Gilson Atlas III front face, each colour section corresponds to one number in the first digit.

Having a spiral of 25 turns, there is a uniform distribution of marks (four digits) along the complete scale.

Special-purpose circular LSSRs

I have already indicated that the purpose of LSSRs is to provide an increase of precision in slide rule calculations. However, in the same way as there are models dedicated only to high-precision multiplications and divisions, there are others focusing on providing precision in other calculations. An example of this is the IGN logarithmic circle [4]. This IGN rule is a 40 cm diameter disc with DF, D and C scales. The purpose of its design was topographic calculations (IGN is the Spanish National Geographic Institute), and so trigonometric operation is the main use (using both sexagesimal and centesimal degrees). In this sense, DF and D are clearly long scales (110 cm):



1.0 – 1.1: 100 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 100 marks.**
Beginning, middle and end sections of the one-decade scale in IGN disc D scale

These are to operate with the Tangent and Sines scales, which are also long-scales. However, the C scale is considered to be secondary, and thus gets a reduced precision and length (72 cm):

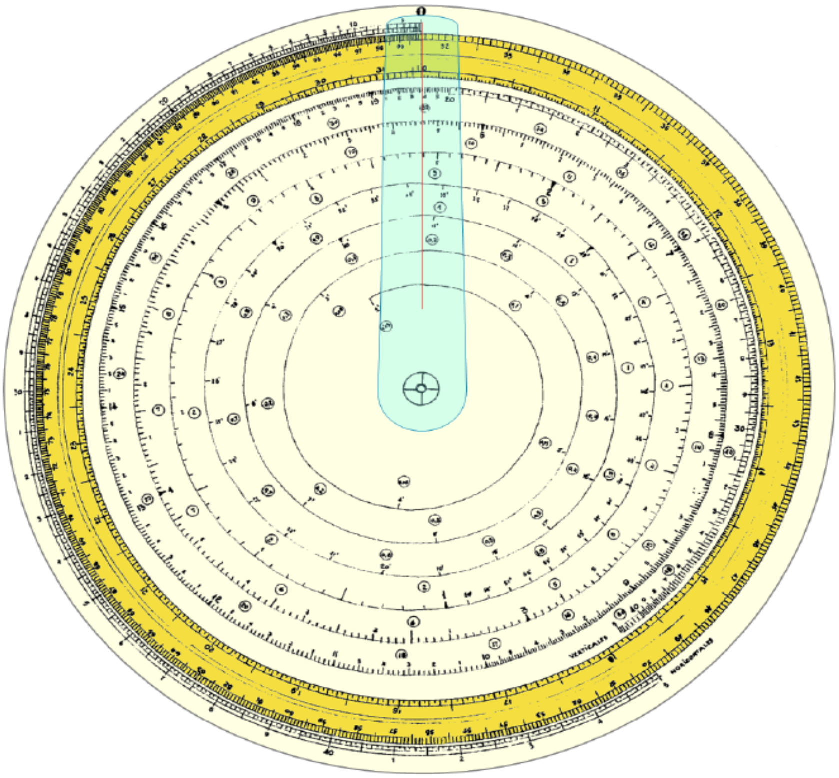
1.0 – 1.1: 10 marks. **3.9 – 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 100 marks.**
Beginning, middle and end sections of the one-decade scale in IGN disc C scale.

Rephrasing the Definition of LSSR

In the Larger Circular LSSRs chapter above, I presented the IGN, an LSSR, having long C and D scales, which matched the lengths of the sines and tangent scales to that of the C scale. So, now we should go a little further and consider, just like some designs minimized the available scales to prioritize the multiplication and division of numbers, that there may be slide rules where the basic purpose is the multiplication or division of some functions, specific for a given science or technology.

This leads to a generalization of the definition, and the case of multiplication and division of plain numbers becomes the simplest function. The precision should be compared to that of standard desktop slide rules, although the comparison may be sometimes complex.

For example, again in the field of topography, the Spanish patent ES-0040507_U, by Enrique Díaz, (1954) describes a circular slide rule with a sliding ring having a two-segment C scale (about 150 cm long). In the body, then, outside the slide there is a $\cos^2$ scale, and inside there is a 6-turn spiral of a sin*cos scale. The calculations are done starting and ending in the C scale, providing clearly higher precision than what could be done with a desktop 25cm-scale device. However, there is no provision for simple multiplication or division.



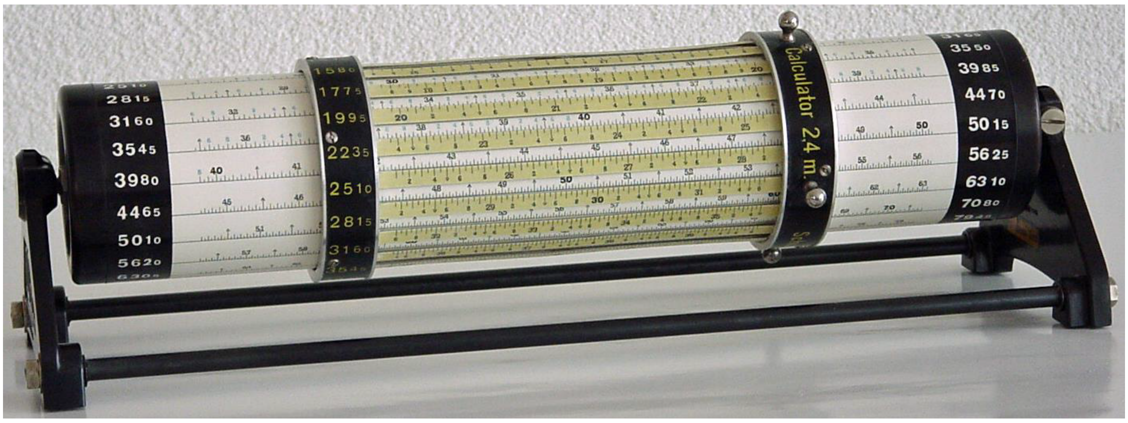
1.0 – 1.1: 50 marks. 3.9 – 4.0 – 4.1: 10 marks. 9.0 – 10.0: 100 marks.

Circular disk with long scales shown in ES-0040507_U (in yellow, the slide with the 2-segment C scale).

Linear Cylindrical LSSRs

Until now we have seen flat, two-dimensional, devices. These are more or less easy to handle, to manufacture or to transport. In the search for larger surfaces in small volumes, three-dimensional shapes were considered and, I guess the cylinder provided the best alternative. However, manufacturing on a cylinder is somewhat complicated and so, this alternative was mostly dedicated only to long-scale slide rules.

The first type took the design of the gridiron slide rule, and “wrapped” it in a cylinder. In this way the number of “rods”, now printed scale segments, could be greatly increased without compromising the operation, directly improving the precision.



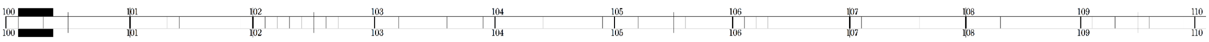
Loga RW Cylindrical 2.4m, with a 20-segment scale.

Considering the dimensions of a desktop device, with a maximum length more or less fixed, the diameter was the variable to increase when more segments were fitted into the device. As can be seen in the previous picture, however, the devices were complex and the cost increase should imply a clear precision improvement. Thus, a common device would range from forty or fifty segments with a scale length of ten meters, to eighty segments with a scale length of twenty-four meters.

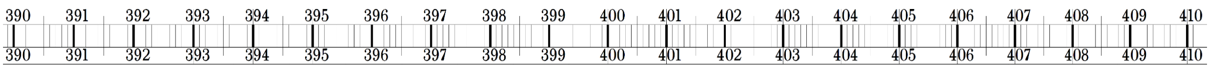
Another approach to the cylindrical gridiron is the Thacher type, where the slide rods get a triangular shape, to increase the surface area even more, and enable the use of more than one scale.

K+E 4012 Thacher cylindrical slide rule (refurbished with new scales by Bob Wolfson).

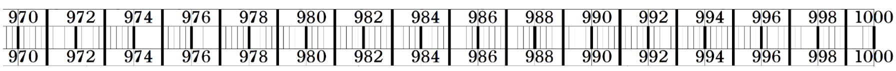
Although the cylinder dimensions were smaller than the ones previously shown, the K+E 4012 had forty segments and a scale length of a little more than nine meters. On Bob Wolfson's website, there are pdf files with the scale layout for both the body and the slide (sites.google.com/site/bobscalculatorsandsliderules):



1.0 – 1.1: 100 marks.



3.9 – 4.0 – 4.1: 100 marks.



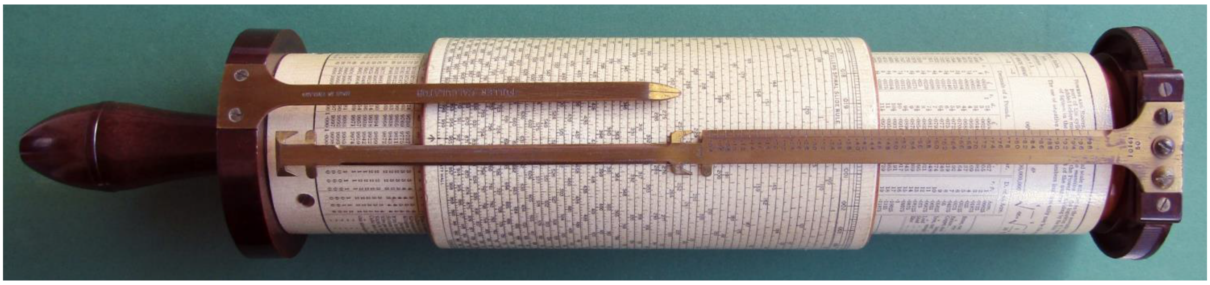
9.0 – 10.0: 500 marks (9.9 – 10.0: 50 marks).

Beginning, middle and end sections of “A” scale in K+E 4012 Thacher slide rule.

Nevertheless, in these types of LSSRs, the calculating process was a little complex given the need to move around so many scale segments. So, different means to facilitate finding the right segment, or to mark where a needed number is placed, etc. were provided.

Helical Cylindrical LSSRs

We have already seen that a spiral in a disc provides a nice-looking scale which is much easier to work with than segmented scales. The same occurs in the cylindrical domain, but the scales are now like a helix turning on the surface and around the cylinder axis. There are two types of construction. The first one has a single helical scale and two cursors to work with. The best known of these are the Fuller slide rules; here is shown the type I:



1.0 – 1.1: 100 marks. **3.9 – 4.0 – 4.1: 100 marks.** **9.0 – 10.0: 500 marks.**

Fuller type I slide rule

The most common Fuller slide rules had a 20-turn scale with a 12.7-meter length. To avoid needing a fixed stand that would prevent picking up the rule, for example, over the work surface where the calculations were being performed, a metal rod was added to the wooden box to act as a temporary stand. This provided easy usage and helped the design to last more than eighty years.

The second type of construction has two concentric cylinders, each with at least one helical scale. Over these, a third cylinder acted as cursor, normally having two indicating lines. The second and third cylinders are transparent in some cases to enable seeing the scale on the inner cylinder. The most common in this type are the telescopic Otis King slide rules:

1.0 – 1.1: 100 marks. **3.9 – 4.0: 15 marks; 4.0 – 4.1: 10 marks.** **9.0 – 10.0: 100 marks.**

Otis King model K.

The best selling model, the model K, has a central cylinder with one 20-turn, 80 cm long scale, and an inner cylinder with twice that scale. The external cursor cylinder is metallic with an indicator mark (or two) at each of its rims. This was quite a light-weight and portable device, (about 15 cm when closed), but I guess that having the numbers so closely packed together made it difficult for the scales to be read in practice.

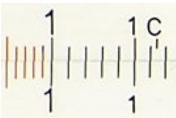
An advantage of this type of LSSR over circular discs is that you look for a number nearly horizontally, from left to right, just as in a book, while firmly holding the rule with one hand (it is necessary to continuously rotate a slide rule disk), but the spiral on a disk has the property of an increasing distance between marks on the outer turns, thus improving the precision at the end of the scale.

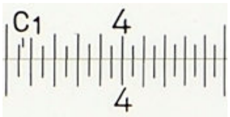
Pocket LSSRs?

Another need the slide rule manufacturers had to consider was very easy portability, with reduced size and weight, to enable fast calculations everywhere. This led to pocket-sized rules, and the result was a loss of precision.

The standard sized pocket linear slide rule incorporates scales of 12.5 cm and this, clearly, does not enable the precision that a desktop slide rule, with 25 cm scales, provides. So, it seems contradictory to speak about "LSSRs fitting into pockets"!

However, the fact is that manufacturers tried to provide some improvements in precision even at such small sizes. In this case, however, the "standard" for comparison has to be the 12.5 cm C & D scales:





1.0 – 1.1: 5 marks. 3.9 – 4.0 – 4.1: 2 marks. 9.0 – 10.0: 10 marks.
Beginning, middle and end sections of C and D scales in a 12.5 cm slide rule

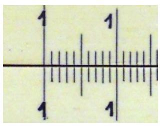
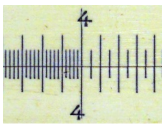
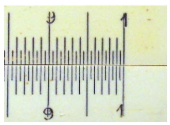
From this chapter I will exclude the pocket cylindrical versions, as these go far beyond the limits we will be discussing here (and are already included in the respective previous chapter).

Pocket Linear LSSRs

The same alternatives as for the 25-cm models apply here. Nevertheless, only dimensions smaller than 25 cm should be considered. To begin with there are models of 20 cm (8 inches), like the WN 87, (and other Japanese models like the Fuji 806 or the Hemmi 43A), that have C and D scales with the same precision as a 25-cm scale; however, it might not be obvious whether to consider them to be small (student) desktop rules or pocket LSSRs. Maybe we should specify a desktop "dimension range" from 20 cm to 36 cm or similar…

Then, there is the alternative of including scales divided into segments, and the most common is the 2-segment scale, like the W-W' scales in the Faber Castell 62/83, copying the desktop model; the number of marks is, again, the same as on a 25 cm specimen.

A different case might be Nestler 12b which still has a 12.5 cm scale, but which increases the number of marks to match those of the scales on a desktop device:

1.0 – 1.1: 10 marks. 3.9 – 4.0: 5 marks; 4.0 – 4.1: 2 marks. 9.0 – 10.0: 20 marks.
Beginning, middle and end sections of C and D scales in Nestler 12b slide rule.

The trick, here, is that this scale is accompanied by a cursor with a magnifier. So, the result of the system may provide a precision like a 25-cm pair of scales. However, I think this should not be considered an LSSR, as we are not considering the help of a magnifier in our definition (a magnifier could be added to any slide rule). Or maybe we should add another class of LSSRs equipped with magnifiers... Nevertheless, it is a very nice pocket specimen!

Pocket Circular LSSRs

Although we should define a standard dimension for pocket circular slide rules, “pocket-sized” for a circular disk is somewhat fuzzy, as some models considered to be “desktop” might nearly fit in a pocket.

Nevertheless, making the same approach as with desktop models, a 12.5-cm scale would fit in a 4-cm diameter circle. Considering C/D scales at 2/3 of the total would provide six centimetres as the external diameter of a circular slide rule capable of being considered as suitable for an average pocket. Then, the absolute maximum would be a diameter of 8 cm, the circumference needed for a 25-centimetre scale.

So, we could consider as big, pocket slide rules with diameters from 6 to 8-centimetres. This is the case with the SIC 250, a disc with an outer diameter of 8 cm, and C & D scales of nearly 19 cm, also having the same precision as a 25-cm scale. Then, SIC 250 might be a pocket LSSR, but can also be a smaller desktop disc, with the same design as for the equivalent 20-cm linear slide rules.

Apart from that, the fact is that circular LSSRs are clearly distinguishable by being of the multi-segment or the spiral type, with lengths clearly over 12.5 cm even in the smaller models.

This Bibliography applies to both Part 1 and Part 2 of this paper.

Bibliography

1. Chamberlain, Edwin J.: *“Long Scale Slide Rules”*, Journal of the Oughtred Society, 1999, Vol. 8.1, P. 24.
2. Chamberlain, Edwin J.: *“Long-Scale Slide Rules Revisited”*, Journal of the Oughtred Society, 2004, Vol.13.1, P 23. .
3. Fernández, Jose G.: *“Slide Rules “Made in Spain””*, Journal of the Oughtred Society, 2016, Vol. 25.2, P. 7.
4. Fernández, Jose G.: *“The IGN Logarithmic Circle”*, Journal of the Oughtred Society, 2017, Vol. 26.2, P. 7.
5. Chamberlain, Edwin J.: *“The Ross Precision Computer”*, Journal of the Oughtred Society, 2016, Vol. 25.1, P. 11.
6. Aristo-Werke, Dennert & Pape KG: *“100 Years Aristo Slide Rules”*, April 1972 (page 14)
7. Whythe, D.J.: *“The Whythe Complex Slide Rule in Fuller Style”*, Journal of the Oughtred Society, 1999, Vol. 8.1, P. 15.
8. van Riet, Ronald W.M.: *“Position Line Slide Rules: Bygrave and Höhenrechenschieber”*, 2008 .
9. Hopp, Peter M.: *“A Very Early Chinese Slide Rule”*, UKSRC Slide Rule Gazette 2001, Iss. 2, P. 19
10. Babcock, Bruce E.: *“Two Noble Attempts to Improve the Slide Rule”*, Journal of the Oughtred Society, 1995, Vol. 4.1, P. 41.
11. Schure, Conrad: *“The Nystrom Calculator – The First Patented American Slide Rule”*, Journal of the Oughtred Society, 2007, Vol. 16.2, P. 3.